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FINAL REPORT

TRAN*STAR II EVALUATION FOR NOAA DATA BUOY OFFICE

AUGUST 1976

National Aeronautics and Space Administration

National Space Technology Laboratories

Engineering and Science Services Laboratory

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Prepared
by

National Space Technology Laboratories
Engineering and Science Services Laboratory
Bay St. Louis, Mississippi 39520

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PART A - SUMMARY

1.0 OBJECTIVES

The overall objective of the effort conducted as a part of TWR DB-2613 is to evaluate the capability of the TRAN*STAR II receiver equipment utilizing the U.S. Navy Navigational Satellite System to provide reliable position locations with reasonable accuracy and frequency.

To satisfy this objective an evaluation plan was prepared (See Appendix A), two receivers, an antenna and a test set were procured, and position fix data collected at NSTL from a fixed known location during the months of May and June. The data was then processed through a computer program, analyzed and a report prepared.

2.0 SUMMARY

The results of the evaluation are summarized below:

1. No known TRAN*STAR II equipment failures were observed during the evaluation period.
2. Position fixes were obtained on a two shift 5 day week basis during May and June. During May 91 position fixes were obtained utilizing receiver number 7 and 62 of these fixes had an error of no more than 6 km*. During June 93 position fixes were obtained utilizing receiver number 5 and 70 of these fixes had an error of no more than 6 km. The mean time between fixes was approximately 3.5 hours in May and 3.0 hours in June. The mean time between good fixes was approximately 5.2 hours in May and 4 hours in June. Eighty percent of the fixes during May and June were from 3 of the 6 navigational satellites (30120, 30140 and 30190).
3. The reasons for not obtaining accurate fixes as determined by the computer program and analysis of the data were as follows:

No.	Reasons
11	Position fix error greater than 6 km
12	Doppler error between theoretical and actual greater than 50,000 Doppler counts.

* 6 km value based on Chauvenet's criterion (Appendix A, Section 7-7).

12	No satellite above the horizon at one minute after lock-on.
6	Satellite lost lock and/or set.
3	No fix obtained
2	Teletype errors of orbital parameters
2	Less than 3 good Dopplers obtained
1	Residuals > 2000 meters
1	Doppler test data incorrect
1	Doppler not ascending
1	No time word in the data
Total 52	

Additional analysis was conducted to evaluate these reasons in more detail.

- o Ten of the eleven fixes that had errors greater than 6 km were taken on satellite passes that had a maximum elevation angle greater than 63 degrees.
- o The overflow of the time buffer in the test equipment after 17 hours 4 minutes resulted in timing errors for the first fix taken after each of the 9 weekends of the test.
- o The computer subroutine MATCH rejected good Doppler data in at least three instances due to its logic not being able to handle all test cases.
- o Teletype errors were discovered on the orbital parameter hard copy printout and resulted in no fixes being obtained in two known instances.
- o Test data was manually shifted out of the test set and the nine 8 character words on the LED* display read and recorded sequentially by the data technicians one word at a time as described in the test plan. Several errors in the data were observed that were probably due to human mistakes.
- o In two instances, less than 3 valid Dopplers were received for a fix.

4. The measured latitude and longitude of the test receiver site were:

Latitude	30^{o} 21.99'
Longitude	-89^{o} 36.98'

*Light Emitting Diode.

The positioning performance of the May and June tests with respect to the estimated position were as follows:

Month	MAY	JUNE
Receiver Number	7	5
Number of Fixes	62	70
Latitude Bias (km)	-0.054 (South)	-0.54 (South)
Longitude Bias (km)	-0.027 (West)	0.18 (East)
Radial Bias (km)	0.06 (200 ft)	0.57 (1870 ft)
Latitude Std Dev (km)	1.94	1.69
Longitude Std Dev (km)	2.21	2.15
Radial Std Dev (km)	2.9	2.7

5. The position fix data was processed utilizing 40 different random initial position estimates that were all within a 230 km distance of the estimated position. The results were similar. The computer program required an average of 3.6 iterations instead of the 2.8 averaged utilizing the known position.

6. It was determined that the fiducial time delay of 75 milliseconds caused by equipment filtering was too short. This time delay which is a constant in the computer program was increased to minimize this error and the standatd deviation was reduced as follows:

	MAY	JUNE
Fiducial time delay (msec)	369	333
Latitude Std Dev (km)	.90	.73
Longitude Std Dev (km)	2.11	2.08
Radial Std Dev (km)	2.29	2.21

3.0 CONCLUSIONS

The following conclusions are drawn from the evaluation.

1. The TRAN*STAR hardware is reliable. No equipment failures were observed during the evaluation which lasted for two months on a two-shift 5-day basis.

2. The position fixes taken at NSTL during May and June had a standard deviation of between 2 and 3 kilometers. The longitude standard deviation is larger than that for the latitude.

3. The fiducial time delay which is caused by the equipment and is corrected in the computer program should be changed from 75 to approximately 350 milliseconds to agree with the hardware. The tolerance on this time delay should be held to ±10 percent (±35 milliseconds) to hold this error to ±0.2km. This can be accomplished in the hardware and/or software.

4. The average time between fixes was approximately 3.2 hours and between good fixes was 4.6 hours. With an automated production system and the receiver located in the vicinity of NSTL the average time between good fixes should be between 3-4 hours.

5. The TRAN*STAR II system in its present form is adequate for R&D evaluation but is not an operational system. In addition to integrating the receiver with DCPRS, the data transmission capabilities of the NOVA-840 should be utilized to receive the orbital parameters and the observational data directly or else the receiver at NSTL should be modified to receive the twice daily orbital parameter updates from the satellites. A data base should be established on the NOVA 840 for the orbital parameters and the observational data. An additional data base to store position fixes and to provide data to be utilized for calculating estimated buoy position for drifting buoys is also required. The MATCH subroutine should be modified to handle more cases and checked out with actual data. These changes are considered to be routine in making a system operational.